Nationaal Lucht- en Ruimtevaartlaboratorium

National Aerospace Laboratory NLR

Executive summary

GNSS Verification, Validation and Security

In Support of Satellite Navigation Infrastructure, Services & Applications

Problem area
With the EGNOS system close to operational readiness and the go-ahead of the Galileo In-orbit Validation Phase end of 2004 an important new phase in the development of Europe's contribution to GNSS has started.

Several institutes and industries in the Netherlands have been involved - and plan a growing involvement - in the development of the GNSS infrastructure presently under management of GJU, ESA and Galileo Industries

Description of work
A teaming initiative between The National Aerospace Laboratory NLR, LogicaCMG Nederland B.V., Dutch Space B.V. and the Netherlands Organization for Applied Scientific Research TNO has been taken in 2004 to address the verification, validation and security aspects of GNSS. Objective is to jointly contribute in this area in the Galileo Programme and to ensure that the knowledge and expertise gained from various GNSS projects will be made available in an effective and efficient way for the development of GNSS systems such as Galileo.

Results and conclusions
With the present and growing knowledge on the verification, validation and security issues in GNSS, this team aims to establish a centre of competence on certification and accreditation of GNSS infrastructure and services. This will include Galileo and associated elements.

Applicability
Through co-operation with similar initiatives in other countries, the team hopes to establish an international co-operation in making Galileo a success

Report no.
NLR-TP-2006-015

Author(s)
P. Dieleman MSc,
R. Postema MSc,
F.J. Teule MSc and
J. Huizenga MSc

Classification report
Unclassified

Date
February 2006

Knowledge area(s)
Ruimtevaart

Descriptor(s)
Satellietnavigatie
Verificatie
Validatie
Security
Certificatie
Galileo

Nationaal Lucht- en Ruimtevaartlaboratorium, National Aerospace Laboratory NLR

Anthony Fokkerweg 2, 1059 CM Amsterdam,
P.O. Box 90502, 1006 BM Amsterdam, The Netherlands
Telephone +31 20 511 31 13, Fax +31 20 511 32 10, Web site: 27Hwww.nlr.nl

Nationaal Lucht- en Ruimtevaartlaboratorium
National Aerospace Laboratory NLR

NLR-TP-2006-015

GNSS Verification, Validation and Security

In Support of Satellite Navigation Infrastructure, Services & Applications

P. Dieleman, R. Postema[1], F.J. Teule[2] and J. Huizenga[3]

[1] LogicaCMG BV

[2] Dutch Space BV

[3] TNO Telecom

This report is based on an article published in the European Journal of Navigation, Volume 3, Number 4, November 2005.

Customer	National Aerospace Laboratory NLR
Working Plan number	AS.1.I
Owner	National Aerospace Laboratory NLR
Division	Aerospace Sytems & Applications
Distribution	Unlimited
Classification of title	Unclassified February 2006

Approved by:

Author	Reviewer	Managing department
6/1/06	7/1/06	7/1/06

Contents

GNSS Verification, Validation and Security

In Support of Satellite Navigation Infrastructure, Services & Applications

By Peter Dieleman, National Aerospace Laboratory (NLR), e-mail: dieleman@nlr.nl,
Rob Postema, LogicaCMG Nederland B.V, e-mail: rob.postema@logicacmg.com,
Frits Teule, Dutch Space B.V., e-mail: f.teule@dutchspace.nl, and
Jan Huizenga, TNO Telecom, e-mail: J.Huizenga@telecom.tno.nl

With the EGNOS system close to operational readiness and the go-ahead of the Galileo In-orbit Validation Phase end of 2004 an important new phase in the development of Europe's contribution to GNSS has started.

Several institutes and industries in the Netherlands have been involved - and plan a growing involvement - in the development of the GNSS infrastructure presently under management of GJU, ESA and Galileo Industries. A teaming initiative between The National Aerospace Laboratory NLR, LogicaCMG Nederland B.V., Dutch Space B.V. and the Netherlands Organization for Applied Scientific Research TNO has been taken in 2004 to address the verification, validation and security aspects of GNSS. Objective is to jointly contribute in this area in the Galileo Programme and to ensure that the knowledge and expertise gained from various GNSS projects will be made available in an effective and efficient way for the development of GNSS systems such as Galileo. With the present and growing knowledge on the verification, validation and security issues in GNSS, this team aims to establish a centre of competence on certification and accreditation of GNSS infrastructure and services. This will include Galileo and associated elements.

Introduction

With an improved availability, accuracy, integrity and security, Galileo will open opportunities for the development of improved and new services and applications. Extensive knowledge on many aspects of the Galileo System is mandatory to develop new services and applications, and - in case of safety or mission critical examples - certify and accredit these services. Also a variety of verification, validation, certification and accreditation standards, methods and tools is required to support this.

To adhere to this perspective, four of the main space organizations in the Netherlands have teamed up to address Verification, Validation and Security, with the objective to successfully implement Galileo and to stimulate its use in the Netherlands.

Objective, purpose

The objective of this paper is to present the contribution of a co-operative effort of NLR, LogicaCMG Nederland B.V., Dutch Space B.V. and TNO to the roadmap towards a successful implementation and use of Galileo, in particular in the Netherlands.

Background

Introduction of EGNOS and Galileo

With the introduction of EGNOS and the start of the Galileo development, new opportunities arise to develop services and applications, requiring accurate and reliable positioning and timing information. In comparison with the existing Global Navigation Satellite Systems (GNSS) - primarily based on GPS - EGNOS and Galileo offer additional integrity and security services with guaranteed availability. This can be included in the development of downstream services and applications. Integrity may be introduced in services required for mission and safety critical applications like aviation, or in applications with a high commercial interest, where liability issues play a significant role. Security may be needed to prevent fraud in the use of the application. Moreover, the combination of integrity of information provision and security related to this information will make it feasible to introduce Galileo in safety and mission critical applications and services with a high commercial interest, thereby extending the range which is now in operation based on GPS alone.

In the majority of these cases, this will mean that downstream services and applications may need certification and/or accreditation before they can be made operational. Certification and accreditation needs to be performed against the standards applicable to the domain in which the application is introduced. E.g. for introduction of Galileo in Railway Safety Systems, the application needs to be certified according to the CENELEC standards. For avionics, MOPS and SARPS standards have to be met.

Challenge

For a successful implementation and use of Galileo – and EGNOS – in mission and safety critical services and applications, certification and accreditation is an essential step in the development and release of the service.

For certification and accreditation, the standards applicable to the services impose requirements on the development processes and methods use to establish the service. Throughout the development, compliance with these requirements needs to be verified and validated.

The verification and validation during the development of a service will need both detailed knowledge of the Galileo system and knowledge of the application domain, to arrive at a successful certification and/or accreditation of the service for its release and operational use.

Dutch contribution to EGNOS and Galileo

Over de past years, different organisations from the Netherlands have contributed to the European activities in the area of GNSS infrastructure developments. This applies to both EGNOS and Galileo. The background knowledge on GPS (and Glonass), including augmentation – both from civil and military use – further supports this.

The Netherlands contributes financially to the EGNOS and Galileo initiatives, with the objective to use the experience and competence gained in the successful implementation and use of the systems in The Netherlands. To achieve this objective, industry in The Netherlands focuses its contribution on areas that allow and enable this use at a later stage. It also requires gaining knowledge of the systems and their potential.

To arrive at this objective, NLR, Dutch Space and TNO have commenced the Valileo initiative at an early stage of the Galileo development, with the ambition to evolve into a recognized Center Of Competence for GALILEO Verification and Validation in Europe. The objective being:

- Support the Galileo Prime developer as a principal Galileo verifier in the development of the GALILEO core system;
- Support validation of Galileo-based application development;

With the participation of LogicaCMG Nederland B.V. in the Galileo Phase C0 programme, another organization was introduced.. Based on the joint knowledge of all organisations, it was agreed to broaden the scope of activities in a co-operation addressing Verification, Validation as well as Security of GNSS and its services and application, with an initial focus on the Galileo Programme.

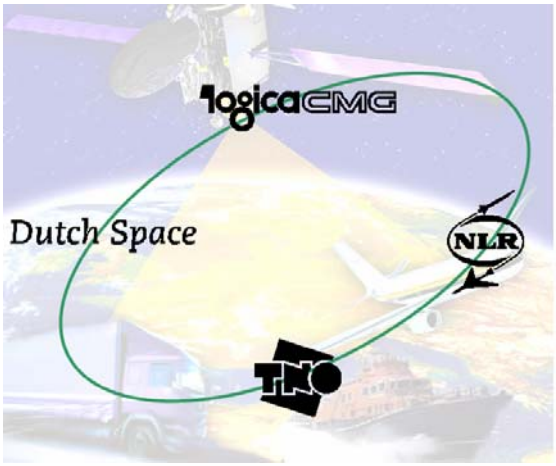


Figure 4.2: Teaming in the Netherlands for the Verification, Validation & Security of GNSS/Galileo, and its applications and services.

A Dutch Team for Verification, Validation and Security of Galileo

Objectives

Bearing in mind the need for certification and accreditation of Galileo and its applications and services, the above organisations have joined forces in a teaming agreement, see figure 4.1, to address the verification, validation and security aspects of GNSS. With the co-operation, the team wants to ensure that the knowledge and expertise gained from various GNSS projects can and will be made available in an effective and efficient way for the development of GNSS systems such as Galileo, and its applications and services.
With the teaming, challenges in the area of verification, validation and security of GNSS infrastructure and downstream applications, can be addressed in an efficient and effective way, making available the required expertise from a large pool of experience.

With this cooperation, the team hopes to contribute to the successful implementation and use of Galileo in the following ways:

- To obtain and disseminate knowledge of the Galileo System which is relevant for – potential – users of the Galileo System,

- To obtain experience on verification and validation of the Galileo System, the applicable processes and methods, in order to perform the certification of the safety and mission critical applications and services based on service provided by the Galileo infrastructure,
- To support the accreditation of secure applications based on the knowledge gained in the development of the Galileo security architecture and Key Management Facilities.

As such, the team focuses on providing their services in the verification, validation and security activities of Galileo. This may be on system, segment, or element level. Following this, the team will address these issues in the development of services and applications.

Participants

The National Aerospace Laboratory NLR NLR is the central institute for aerospace technology in the Netherlands. Activities in the area of satellite navigation fit into NLR's aims to contribute to space applications and to the development of advanced navigation technology and infrastructure, to the benefit of air transport and other transport modes. NLR participates in many international projects, often in collaboration with industries.

NLR has available a great deal of knowledge and experience concerning the Global Positioning System (GPS) and the initiatives for European navigation systems (GALILEO, European Geo-stationary Navigation Overlay System (EGNOS)). Projects include EGNOS AIV and ASQF, Galileo Phase B, C0 and C/D/E1.

LogicaCMG is a major international force in IT services and wireless telecoms. Logica-CMG offers IT solutions and services to a wide scope of markets. With a strong presence in the main market areas, and proven competence in the development of mission critical systems applications and services in these markets, LogicaCMG strongly believes in the feasibility of using the space infrastructure, in particular navigation satellites, to address challenges downstream applications and services. LogicaCMG has been prime contractor for the phase C0 for the Galileo Ground Control and Ground Mission Segment. in Galileo phase C/D/E1 LogicaCMG supports GaIn, in the security back office.

Dutch Space B.V. is the largest space company in The Netherlands. Its product range comprises Solar Arrays, advanced structures, such as the Ariane 5 main engine frame, robotics & control systems, such as the European Robotic Arm, the attitude & orbit control systems for Herschel/Planck scientific satellites and the delay lines for ESO’s Very Large Telescope in Chile, instruments for micro-gravity & earth-observation such as the Ozone Monitoring Instrument launched in summer 2004 on NASA’s AURA spacecraft. Furthermore the company delivers simulations and test systems around the EuroSim simulation environment. Through its involvement in Galileo Verification & Validation since the start of the programme, Dutch Space targets expansion in the Space and Ground Mission Segments.

Netherlands Organisation for Applied Scientific Research TNO is a large contract research organization in the Netherlands. TNO has a staff of about 5.500 highly educated and driven professionals. TNO’s mission is to apply technological knowledge with the aim of strengthening the innovative power of industry and government. For new opportunities in the GNSS area TNO Space is the point of contact.

TNO has a track record on IT security and privacy validation and evaluation issues. TNO has made several studies and international conference papers about Information Operations

concerning the critical infrastructures and the evaluation of these infrastructures and their critical applications and services.

Experience

Experience has been gained in the following projects:

- RAMS analysis in phase C0 of the Galileo Ground Control and Mission Segment,
- Specification of the Security Architecture of the Galileo Ground Control and Mission Segment, phase C0,
- Assembly, Integration and Validation planning of the Galileo System (including security aspects) and Ground Segments (including the Ground Control and Mission Segment) during phases B and C0.
- Definition of tooling and facilities, and the development of V&V strategies of the Galileo Ground Mission segment.
- Verification of EGNOS performance through dynamic tests (Flight Trials)
- Certification of Road Management applications of EGNOS in the ARMAS phase II project.

Centre of Competence

The co-operation aims to evolve towards a Centre of Competence on certification and accreditation of GNSS, e.g. Galileo, infrastructure and services, based on growing knowledge, integral overview and added value.

To ensure that the knowledge and expertise gained over the past and coming years will be available to various initiatives in the Netherlands, this Centre of Competence for certification and accreditation is now being further defined. The development of this centre is planned and under discussion as part of the co-operation, supported by Dutch Government and NIVR. The teaming leaves room for additional companies to join, where especially SME's are invited to get involved. Objectives of the centre derived from this scope are to:

- Collect, manage and disseminate knowledge on GNSS services and infrastructure;
- Support verification and validation of the Galileo system and services, Local Elements, application using GNSS, including integrated systems;
- Support validation of GNSS services and applications;
- Provide services related to GNSS service availability, both historically and predicted - closely linked to services provided by the Galileo operator;
- Support next-generation definition and developments for GNSS.

The Centre of Competence will address the need of different types of customers, in relation to its objectives. The following list provides a non-exhaustive list of the potential customers:

- Users of the Galileo signal, who will have an advantage to use the Galileo positioning and timing signal to improve and optimise their business processes, e.g. road and railway operators;
- Service Providers, who will use the Galileo positioning and timing signal to provide services and applications to their markets, e.g. Location Based Services;
- (Local) Authorities, aiming at;
  - the use of Galileo to support their policy, e.g. virtual tolling for the Department of Transport,
  - promotion of the use Galileo e.g. by the government;

- SME's and R&D organisations, for which the GUC can provide access to equipment and testing and simulation tools, to support innovation, and development of new products reducing the necessary investments for SME's;
- Educational Organisations, providing an environment for familiarisation, promotion, training, and research and development;
- Galileo Concessionaire, for which the Centre of Competence can serve as an intermediary to provide their services and management of the local components.

A Road Map to support Application Development

Introduction

The co-operation and Centre of Competence indicated in the previous section are considered to be – essential – elements to arrive at the implementation and use of EGNOS and Galileo in The Netherlands. In parallel, several complementary initiatives have been started or a planned. The following initiatives have been identified and are shortly described:

- A Dutch User Platform for Satellite Navigation, presently under initiation by the Netherlands Institute for Aerospace Development – NIVR –. The objective is to promote, identify and quantify the need for Galileo services and applications in The Netherlands;
- A newly planned GNSS/Galileo Utilisation Centre, to support organisations in the familiarisation, development and maintenance of downstream GNSS applications and services.

Dutch User Platform for Satellite Navigation

The Dutch User Platform for Satellite Navigation, under definition and initiation by NIVR, brings together potential users, GNSS experts and industrial organisations, covering various application domains, to identify feasible use and business cases for GNSS in The Netherlands.

The mission of the user platform is to stimulate the development of the commercial navigation sector, involve all representatives from the value chain and to jointly establish a roadmap for navigation services and applications.

The objectives of the platform are:

- To enlarge the knowledge pertaining to the potential of satellite navigation satellites;
- To obtain in wider and improved overview of the user need for satellite navigation, and the advantage satellite may offer compared to alternative means;
- To strengthen the position of organisations and industry in The Netherlands in the satellite navigation market;
- To increase the expertise in supporting political decision making, on a national and international level.

The GNSS User Platform will be governed by a steering committee, with the objective to ensure political support for the identified applications and services

Based on the potential of an application or service, working groups will be established to arrive at a business case for the application or services, and road map for its implementation.

The results of the GNSS User Platform will be used by the Centre of Competence and the GNSS User Centre to support their implementation and use

Figure 4.1: Signing of the Teaming Agreement, hosted by The Agency of Aerospace, NIVR.

The Future, a GNSS User Centre

In time, it is envisaged that the Centre of Competence will be integrated in a national Galileo Utilisation Centre – GUC –, joining efforts with the Dutch GNSS User Platform, and providing full services in the development and deployment of GNSS applications and use.
The Galileo Utilisation Centre (GUC) is an independent centre that aims to promote the implementation of the Galileo Mission in services and applications in The Netherlands and thus, contributes to the success of Galileo in this region. By concentrating knowledge and technical facilities easy accessible to various user communities, new services and applications can be introduced effectively and efficiently. Innovative services and products of providers, including SME's, can be generated, enhanced and promoted through this independent platform

With the GUC, the following objectives can be served:

- Promotion of the use of Galileo in The Netherlands;
- Serve as a knowledge centre for Galileo, providing information on e.g. use, quality, service and application development, equipment, standards, interoperability;
- Support the development of new and existing services and applications of Galileo by providing e.g. a development environment, demonstration and test facilities, and simulators;
- Provide manufacturers and service providers to present their solutions for the use of Galileo;
- Training and education for Galileo;
- Communication with and support of Galileo operations, e.g. by development and management of Galileo Local Components;
- Act as a focal point in the Netherlands for pan-European developments (ESA, EU) and initiatives (e.g. Galileo Services).

Such a Utilisation Centre may in itself be part of a pan-European network of User Centres.

Conclusion

With the co-operation described in this paper, the initiation of the Centre of Competence and the contribution to the Dutch User Platform for Satellite Navigation, the participating organisation aim to facilitate and contribute to the successful implementation and use of Galileo in The Netherlands.

In this, the knowledge of GNSS infrastructures and the application domain is essential, with a focus on the certification and accreditation requirements. As such verification, validation and

security within the GNSS programs offer a good opportunity to acquire this knowledge and expertise.
The co-operation in the Netherlands provides an excellent track record in verification, validation and security, and will provide for a solid basis to support the certification and accreditation of both the GNSS infrastructure and its applications and services.

Furthermore, through co-operation with similar initiatives in other countries, the team hopes to establish an international co-operation in making Galileo a success.

References

- Teaming Agreement, press release
- **www.nlr.nl**
- **www.logicacmg.com**
- **www.dutchspace.nl**
- **www.tno.nl**
- **www.valileo.nl**
- **www.nivr.nl**

Biography of the Authors

Peter Dieleman is a graduate from Delft University of Technology, Faculty of Electrical Engineering. At NLR he is responsible for business and project management on GNSS, especially involved in test, verification, validation and security.

Rob Postema is a graduate from the Delft University of Technology, Faculty of Aerospace Engineering. As a Business Consultant at LogicaCMG, he is responsible for business development in downstream applications of space infrastructure. In the area of GNSS he is involved in verification, validation and security of GNSS and its applications and services.

Frits Teule is a graduate from the University of Twente, Faculty of Electrical Engineering, The Netherlands and obtained a Master's degree in European Law and Policy at the University of Portsmouth. He is marketing manager at Dutch Space (formerly Fokker Space), Leiden, The Netherlands.

Jan Huizenga graduated from Delft University of Technology. He is Business Consultant at TNO Information and Communication Technology for the sector Space and Public Safety. He works on new designs for critical networks and validation techniques.

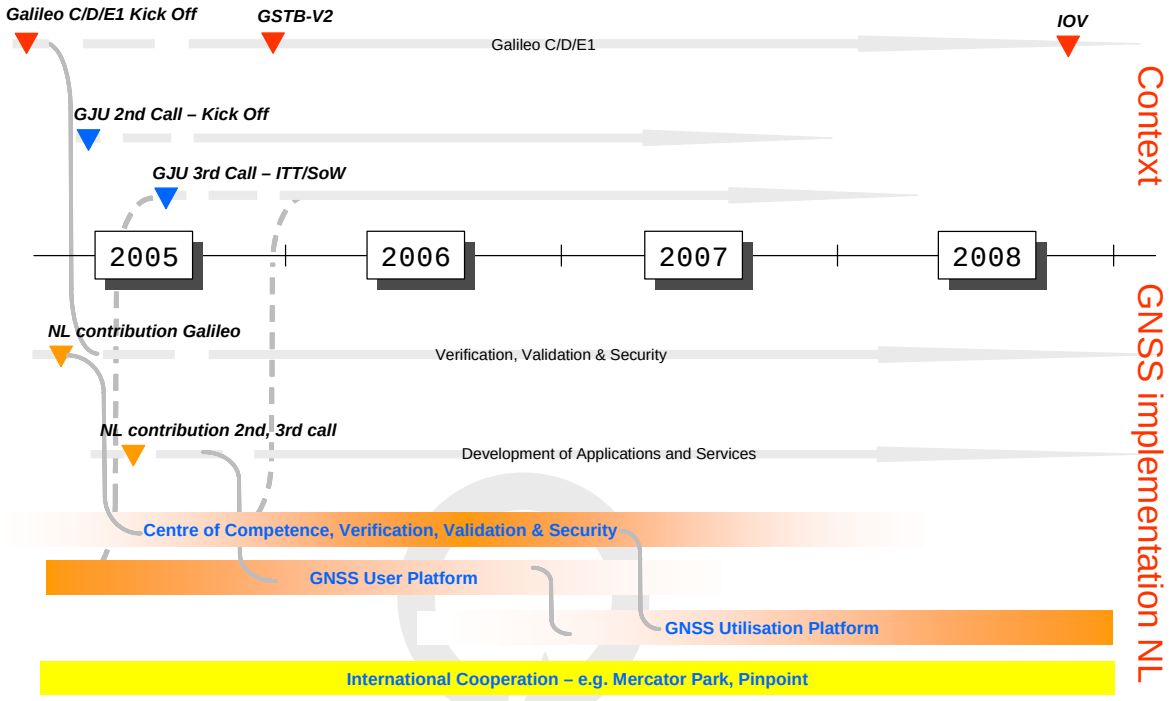
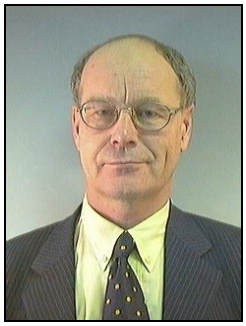


Figure 5.1: The planned and proposed Road Map for the implementation and use of GNSS in The Netherlands, finding connection in the international framework.

Peter Dieleman

Rob Postema



Frits Teule

Jan Huizenga